

NONPROVISIONAL PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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Attorney Docket No.: 107100

Date: August 22, 2000

BOX PATENT APPLICATION

**NONPROVISIONAL APPLICATION TRANSMITTAL
RULE §1.53(b)**

Director of the U.S. Patent and Trademark Office
Washington, D.C. 20231

Sir:

Transmitted herewith for filing under 37 C.F.R. §1.53(b) is the nonprovisional patent application

For (Title): SPREAD ILLUMINATING APPARATUS WITH TRANSPARENT SUBSTRATE
HAVING GROOVE PORTIONS OBLIQUELY ARRANGED AND INTERSECTING ONE
ANOTHER

By (Inventors): Shingo SUZUKI

- ☒ Formal drawings (Figs. 1-9; 4 sheets) are attached.
- ☒ A Declaration and Power of Attorney is filed herewith.
- ☒ An assignment of the invention to Minebea Co., Ltd. is filed herewith.
- ☐ An Information Disclosure Statement is filed herewith.
- ☐ A statement to establish small entity status under 37 C.F.R. §§1.9 and 1.27 is filed herewith.
- ☒ A Preliminary Amendment is filed herewith.
- ☐ Please amend the specification by inserting before the first line the sentence --This nonprovisional application claims the benefit of U.S. Provisional Application No. _____, filed _____.--
- ☒ Priority of foreign application(s) No. 11-235495 filed August 23, 1999 in Japan is claimed (35 U.S.C. §119).
- ☐ A certified copy of the above corresponding foreign application(s) is filed herewith.
- ☒ The filing fee is calculated below:

**CLAIMS IN THE APPLICATION AFTER ENTRY OF
ANY PRELIMINARY AMENDMENT NOTED ABOVE**

FOR:	NO. FILED	NO. EXTRA
BASIC FEE		
TOTAL CLAIMS	14 - 20	= *
INDEP CLAIMS	2 - 3	= *
<input type="checkbox"/> MULTIPLE DEPENDENT CLAIMS PRESENTED		

* If the difference is less than zero, enter "0".

SMALL ENTITY

RATE	FEE
	\$ 345
x 9 =	\$
x 39 =	\$
+130 =	\$
TOTAL	\$

**OTHER THAN A
SMALL ENTITY**

RATE	FEE
	\$ 690
x 18	\$
x 78	\$
+260	\$
TOTAL	\$ 690

- ☒ Check No. 111272 in the amount of \$690.00 to cover the filing fee is attached. Except as otherwise noted herein, the Director is hereby authorized to charge any other fees that may be required to complete this filing, or to credit any overpayment, to Deposit Account No. 15-0461. Two duplicate copies of this sheet are attached.
- ☐ This application is entitled to small entity status. DO NOT charge large entity fees to our Deposit Account.

Respectfully submitted,

James A. Oliff

James A. Oliff
Registration No. 27,075

Thomas J. Pardini
Registration No. 30,411

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Country of Residence:: Japan
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Family Name::
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City of Residence::
State or Prov. of Residence::
Country of Residence::
Inventor Three Given Name::
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State or Prov. of Residence::
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State or Prov. of Residence::
Country of Residence::
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State or Prov. of Residence::
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Application Information

Title Line One:: SPREAD ILLUMINATING APPARATUS WITH
Title Line Two:: TRANSPARENT SUBSTRATE HAVING GROOVE
Title Line Three:: PORTIONS OBLIQUELY ARRANGED AND
Title Line Four:: INTERSECTING ONE ANOTHER

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PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Shingo SUZUKI

Application No.: New U.S. Patent Application

Filed: August 22, 2000

Docket No.: 107100

For: SPREAD ILLUMINATING APPARATUS WITH TRANSPARENT SUBSTRATE
HAVING GROOVE PORTIONS OBLIQUELY ARRANGED AND INTERSECTING
EACH OTHER

PRELIMINARY AMENDMENT

Director of the U.S. Patent and Trademark Office
Washington, D. C. 20231

Sir:

Prior to initial examination, please amend the above-identified application as follows:

IN THE CLAIMS:

Please change the following Claims:

Claim 3, line 1, change "1 or 2" to --1--

Claim 4, line 1, change "1 or 2" to --1--

Claim 5, line 1, change "1 or 2" to --1--

Claim 6, line 1, change "1 or 2" to --1--

Claim 7, line 1, change "1 or 2" to --1--

Claim 8, line 1, change "1 or 2" to --1--

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Please add the following Claims:

--9. A spread illuminating apparatus according to claim 2, wherein said groove portions are substantially triangular in cross section.--

--10. A spread illuminating apparatus according to claim 2, wherein the interval between said groove portions is decreased as the distance from said bar-like light source increases.--

--11. A spread illuminating apparatus according to claim 2, wherein the depth of said groove portions is increased as the distance from said bar-like source increases.--

--12. A spread illuminating apparatus according to claim 2, wherein an angle defined between each of said groove portions and the side of said transparent substrate opposing said bar-like light source is in the range of 10-45 degrees.--

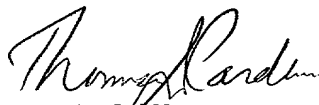
--13. A spread illuminating apparatus according to claim 2, wherein said bar-like light source comprises a bar-like fluorescent tube.--

--14. A spread illuminating apparatus according to claim 2, wherein said bar-like light source includes a bar-like transparent light conductive member and a light emitting diode which is provided at the end portion of said bar-like transparent light conductive member.--

REMARKS

Claims 1- are pending. By this Preliminary Amendment, Claims 3-8 are amended to eliminate multiple dependencies. Claims 9-14 are added to include the subject matter deleted from Claims 3-8. Prompt and favorable consideration on the merits is respectfully solicited.

Respectfully submitted,



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Registration No. 27,075

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JAO:TJP/mgs

Date: August 22, 2000

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DEPOSIT ACCOUNT USE AUTHORIZATION Please grant any extension necessary for entry; Charge any fee due to our Deposit Account No. 15-0461
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[illegible]

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a spread illuminating apparatus for use in a display portion of a personal computer, a word processor or the like (hereinafter, they are referred to as "a personal computer"), or a mobile apparatus, a portable telephone or the like.

2. Description of the Related Art

As for display devices for use in personal computers, heretofore, cathode ray tubes (so-called picture tubes) have been mainly used. However, since these cathode ray tubes are large and heavy and in addition thereto have large power consumption, recently, liquid crystal panels have been employed in many cases. Therefore, the liquid crystal panels each having a large number of pixels have been developed and other circuit elements have been miniaturized, leading to that small personal computers such as a note-book type or the like have rapidly come into wide use. The liquid crystal panels have been often employed as the display devices for use in the mobile equipments, the portable phones or other various electronic equipments in addition to the above-mentioned personal computers.

While the demand for the liquid crystal panels has drastically increased as described above, a suitable illuminating apparatus is required, because the liquid crystal panel itself does not emit the rays of light. Conventionally, in a display device having a relatively large area as in a personal computer, for example, the cold cathode fluorescent lamps (CCF) or the hot cathode fluorescent lamps (HCFL) have been used as the illuminating apparatuses therefor. As for the concrete construction thereof, a square transparent substrate is provided in close proximity to the surface of a liquid crystal panel, the transparent substrate is illuminated by a fluorescent tube which is provided parallel to the side surface

of the transparent substrate, and then the rays of light which are emitted from the fluorescent tube are introduced to the liquid crystal panel which is in turn illuminated with the rays of light introduced thereto.

Since the discharge of electricity is caused between the opposite electrodes in the fluorescent tube, a high voltage for the discharge of electricity is required. For this reason, an oscillation circuit employing a semiconductor device is provided to supply the voltage which is generated on the basis of the oscillation to the fluorescent tube.

Because the personal computer is constructed by combining the electric circuits and the electric apparatuses, the personal computer itself consumes the electric power. Thus, the study for power saving has been made and as a result, currently, the personal computers with remarkably reduced power consumption as compared with the conventional ones have come into wide use. In particular, this tendency is remarkable for the portable personal computers called the note-book type. However, if the amount of power consumption of the illuminating apparatus is large, then the greater part of the electric power generated by the batteries will be consumed in the illuminating apparatus.

On account of this, an illuminating apparatus that employs a white light emitting diode instead of the fluorescent tube has been developed. The patent application of this illuminating apparatus has already been filed with the Patent Office by the present inventors (refer to Japanese Patent Laid-open Publication No. Hei 10-182076). This illuminating apparatus is structured such that a transparent substrate is placed on a liquid crystal panel, a bar-like light conductive member which is made of a transparent material and a part of which is provided with an optical path conversion means is arranged on the end of the transparent substrate, and a light emitting diode is placed on the end portion of the light conductive member in order to emit the rays of light. The rays of light which have been emitted from the light emitting diode are guided from the end portion of the light conductive member into

the light conductive member and then the direction of the emitted rays of light is changed by the optical path conversion means so that the rays of light directly enter the transparent substrate.

Now, whether the bar-like light source is comprised of the fluorescent tube or the combination of the light conductive member and the light emitting diode, it is impossible to brightly illuminate the liquid crystal panel which is arranged in contact with the lower surface of the transparent substrate unless the transparent substrate is uniformly illuminated. Therefore, various ideas have been proposed so far.

Now, an example of a conventional spread illuminating apparatus will be hereinbelow described with reference to Fig. 8 which is an exploded view of the conventional spread illuminating apparatus and Fig. 9 which is a perspective view showing the assembled state thereof. A liquid crystal panel 1 is a reflection type liquid crystal device and has on its surface liquid crystal cells 1a as pixels disposed in a mosaic arrangement. A square transparent substrate 2 is provided close to the upper surface of the liquid crystal panel 1, and a fluorescent tube 3 as a bar-like light source is provided parallel with the side surface of the transparent substrate 2.

In this construction, when the fluorescent tube 3 is lit, the rays of light which have been emitted from the fluorescent tube 3 enter the transparent substrate 2 to illuminate the liquid crystal panel 1 through the transparent substrate 2. In order that the rays of light emitted from the fluorescent tube 3 may be effectively directed toward the transparent substrate 2, a reflection plate 4 is provided behind the fluorescent tube 3.

A large number of groove portions 2a each having a substantial triangle in cross section are provided on the surface of the transparent substrate 2 in such a way as to be parallel with the fluorescent tube 3. Each of the portions which are defined between the adjacent groove portions 2a forms a plane portion 2b. In order to realize the uniformity of the surface light emission, the gaps between the groove portions 2a are large in the vicinity of the fluorescent tube 3 and become smaller as the distance from the

fluorescent tube 3 increases. In addition, the groove portions 2a are shallow in the vicinity of the fluorescent tube 3 and become deeper as the distance from the fluorescent tube 3 increases.

In this connection, when the fluorescent tube 3 emits the rays of light, the rays of light thus emitted therefrom enter the transparent substrate 2 at the side surface thereof and strike against the groove portions 2a to be directed toward the liquid crystal panel 1. However, only the components of the rays of light vertical to the groove portions 2a undergo optical path conversion. Therefore, in Fig. 9, only the components of the rays of light in the direction A are converged, while the components of the rays of light in the direction B parallel with the groove portions 2a are not converged at all. As a result, as shown in Fig. 7, the distribution in the direction B is widely spread. Note that, the rays of light which are directed from the transparent substrate 2 toward the liquid crystal panel 1 are reflected by the liquid crystal panel 1, thereby entering the transparent substrate 2 again to be emitted in the viewing direction.

When the illuminating apparatus for the liquid crystal display device is used in the portable information equipment such as a portable phone, a wide view angle is not required assuming that it is for personal use. The fact is that the rays of light emitted in a wide direction turn out to be useless. Therefore, the useless rays of light emitted in the direction B are converged, whereby it is possible to enhance the front viewing luminance. In order to converge the rays of light emitted in the direction B, additional groove portions need to be formed in the direction perpendicular to the direction of the formation of the existing groove portions. However if the groove portions are formed substantially in parallel with the travelling direction of the rays of light, it is still impossible to converge the rays of light.

If the transparent substrate 2 is provided on the upper surface of the liquid crystal panel 1 as in the above structure, then interference fringes called the Moiré fringes may be generated on the viewing face of the liquid crystal panel 1 in some cases. When

the Moiré fringes are generated, the liquid crystal panel 1 becomes hard to view. It has been discovered that the generation of the Moiré fringes has a close relation with the depth, size and gap of the groove portion 2a of the transparent substrate 2. In addition thereto, it has also been known that the Moiré fringes are generated most intensely when the groove portions 2a are substantially parallel with the direction in which the liquid crystal cells 1a of the liquid crystal panel 1 are arranged.

SUMMARY OF THE INVENTION

In the light of the foregoing, the present invention has been made in order to solve the above-mentioned problems associated with the prior art, and it is therefore an object of the present invention to provide a spread illuminating apparatus in which the rays of light emitted in a transverse direction of the above-mentioned liquid crystal panel and transparent substrate are converged to enhance the luminance, and suppress the Moiré fringes for better viewing.

In order to attain the above-mentioned object, according to a first aspect of the present invention, there is provided a spread illuminating apparatus characterized in that a square transparent substrate is provided close to the surface of a liquid crystal panel, and a plurality of straight groove portions are formed on the surface of the transparent substrate intersecting one another obliquely with respect to the four sides of the transparent substrate.

According to a second aspect of the present invention, there is provided a spread illuminating apparatus characterized in that a square transparent substrate is provided close to the surface of a liquid crystal panel, and the liquid crystal panel is illuminated through the transparent substrate by a bar-like light source which is provided parallel with the side surface of the transparent substrate, wherein a plurality of straight groove portions which are formed on the surface of the transparent substrate intersecting one another obliquely with respect to the four sides of the transparent substrate.

According to a third aspect of the present invention, the spread

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illuminating apparatus of the first or the second aspect of the present invention is characterized in that the groove portions are substantially triangular in cross section.

According to a fourth aspect of the present invention, the spread illuminating apparatus of the first or the second aspect of the present invention is characterized in that the interval between the groove portions is decreased as the distance from the bar-like light source increases.

According to a fifth aspect of the present invention, the spread illuminating apparatus of the first or the second aspect of the present invention is characterized in that the depth of the groove portion is increased as the distance from the bar-like light source increases.

According to a sixth aspect of the present invention, the spread illuminating apparatus of the first or the second aspect of the present invention is characterized in that an angle defined between each of the groove portions and the side of the transparent substrate opposing the bar-like light source is in the range of 10 to 45 degrees.

In addition, according to a seventh aspect of the present invention, the spread illuminating apparatus of the first or the second aspect of the present invention is characterized in that the bar-like light source comprises a bar-like fluorescent tube.

Also, according to an eighth aspect of the present invention, the spread illuminating apparatus of the first or the second aspect of the present invention is characterized in that the bar-like light source includes a bar-like transparent light conductive member and a light emitting diode which is provided at the end portion of the bar-like transparent light conductive member.

As described in the first aspect of the present invention, a plurality of straight groove portions are formed on the surface of the transparent substrate in an oblique direction to the four sides of the transparent substrate, whereby the generation of the Moiré fringes is suppressed due to the groove portions being directed obliquely with respect to the bar-like light source.

In addition, as described in the second aspect of the present

invention, a plurality of straight groove portions are formed on the surface of the transparent substrate intersecting one another obliquely with respect to the four sides of the transparent substrate, whereby the generation of the Moiré fringes is suppressed and in addition thereto, the rays of light which have been emitted from the bar-like light source are converged in the direction parallel with the bar-like light source enhancing the luminance in the viewing direction.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects as well as advantages of the present invention will become clear by the following description of the preferred embodiment of the present invention with reference to the accompanying drawings, in which:

Fig. 1 is an exploded perspective view showing a spread illuminating apparatus of the present invention;

Fig. 2 is a perspective view showing the spread illuminating apparatus of Fig. 1 in an assembled state;

Fig. 3 is a side view showing the structure of groove portions formed on a transparent substrate shown in Fig. 1;

Fig. 4 is a side view showing the structure of another example of groove portions formed on the transparent substrate shown in Fig. 1;

Fig. 5 is an enlarged cross sectional view showing the structure of the groove portions formed on the transparent substrate;

Fig. 6 is a graphical representation showing the field angle characteristics of the spread illuminating apparatus of the present invention;

Fig. 7 is a graphical representation showing the field angle characteristics of a conventional spread illuminating apparatus;

Fig. 8 is an exploded perspective view showing a conventional spread illuminating apparatus; and

Fig. 9 is a perspective view showing the conventional spread illuminating apparatus of Fig. 8 in an assembled state.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the present invention will be hereinafter described with reference to Fig. 1 showing an exploded view and Fig. 2 showing an assembled view. A liquid crystal panel 1 is a reflection type liquid crystal device having on its surface liquid crystal cells 1a in a mosaic arrangement which are to form pixels. A square transparent substrate 2 is provided close to the surface of the liquid crystal panel 1, and a fluorescent tube 3 as a bar-like light source is provided parallel with the side surface of the transparent substrate 2. In this construction, when the fluorescent tube 3 is lit, rays of light which have been emitted from the fluorescent tube 3 enter the transparent substrate 2 to illuminate the liquid crystal panel 1 through the transparent substrate 2. In order to effectively direct the rays of light emitted from the fluorescent tube 3 toward the transparent substrate 2, a reflecting plate 4 is provided behind the fluorescent tube 3.

A plurality of straight groove portions 2a each having a substantial triangle shape in cross section are formed on the surface of the transparent substrate 2 in such a manner as to intersect one another obliquely with respect to the four sides of the transparent substrate 2. The groove portions 2a are substantially triangular in cross section as shown in Figs. 3 and 4, and the interval between the groove portions 2a decreases as the distance from the fluorescent tube 3 increases as shown in Fig. 3. In addition, as shown in Fig. 4, a construction in which the depth of the groove portions 2a increases as the distance from the fluorescent tube 3 decreases may also be adopted. Further, an angle θ defined between each of the groove portions 2a and the side of the transparent substrate 2 opposing the fluorescent tube 3 is set to range from 10 to 45 degrees.

In the above-mentioned construction, when the fluorescent tube 3 emits rays of light, the rays of light thus emitted therefrom enter the transparent substrate 2 at the side surface of the transparent substrate 2, then strike against the groove portions 2a and are directed toward the liquid crystal panel 1. When the

rays of light are reflected by the liquid crystal panel 1, they again enter the transparent substrate 2 and penetrate the transparent substrate 2 to be emitted in the viewing direction. In this case, since the groove portions 2a formed on the transparent substrate 2 are arranged in such a manner as to intersect one another obliquely with respect to the four sides of the transparent substrate 2, the rays of light are converged to increase the peak luminance. That is, while only the components of the rays of light vertical to the groove portions 2a are converged, in the case where the groove portions 2a are formed intersecting one another as in the present structure, all of the rays of light constitute the vertical component to the groove portions 2a, whereby the components of the rays of light in the direction A and in the direction B in Fig. 2 are converged to increase the peak luminance. In addition, since the groove portions 2a are not parallel with the liquid crystal cells 1a of the liquid crystal panel 1, the generation of the Moiré fringes is suppressed.

Now, an actual product of the spread illuminating apparatus will be hereinbelow described with reference to Fig. 5. In order to obtain the transparent substrate 2, a board which is made of acrylate resin with 1 mm thickness is cut into a piece of 80 mm by 60 mm. In addition, as for the shape of the groove portion, angle α in the bottom portion is set to 50 degrees and angle β of inclination with respect to the plane portion 2b is set to 48 degrees. Also, the pitch of the groove portions is fixed to 0.32 mm, and the depth of the groove portions is made to gradually increase from 8 μ m up to 30 μ m.

In the light emission distribution of the rays of light in the direction A and in the direction B which were described with reference to Fig. 2, the light emission distribution range of the direction B turns out to be close to that of the direction A as shown in Fig. 6, and as a result, the peak luminance is enhanced by about 30 %. In the conventional spread illuminating apparatus, the light emission distribution curve about the direction A is too sharp and the view angle in the direction B is too wide resulting

in reduced amount of rays of light emitted as shown in Fig. 7, whereas in the spread illuminating apparatus of the present invention, the light emission distribution curves about the direction A and the direction B as shown in Fig. 6 are similar to each other, thereby enhancing the entire luminance of the transparent substrate.

In the embodiment described above, the fluorescent tube is employed as the bar-like light source. Alternatively, the bar-like light source may also be constructed by a bar-like transparent light conductive member and a light emitting diode which is provided at the end portion thereof, in which case the same effects can be obtained.

The spread illuminating apparatus according to the the first and second aspects of the present invention can suppress the Moiré fringes and also enhance the luminance of a transparent substrate. In addition, by applying the construction described in the third to seventh aspects of the present invention, the above effects can be further enhanced. Also, when the bar-like light source as described in the eighth aspect of the present invention is employed, it is possible to achieve the above-mentioned effect with the power consumption reduced.

While the present invention has been particularly shown and described with reference to the preferred embodiment and the specified modifications thereof, it will be understood that the various changes and other modifications will occur to those skilled in the art without departing from the scope and true spirit of the invention. The scope of the invention is therefore to be determined solely by the appended claims.

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WHAT is claimed is:

1. A spread illuminating apparatus, wherein a square transparent substrate is provided close to the surface of a liquid crystal panel, and a plurality of straight groove portions are formed on the surface of said transparent substrate intersecting one another obliquely with respect to the four sides of said transparent substrate.
2. A spread illuminating apparatus in which a square transparent substrate is provided close to the surface of a liquid crystal panel and said liquid crystal panel is illuminated through said transparent substrate by a bar-like light source which is provided parallel with the side surface of said transparent substrate, wherein a plurality of straight groove portions are formed on the surface of said transparent substrate intersecting one another obliquely with respect to the four sides of said transparent substrate.
3. A spread illuminating apparatus according to claim 1 or 2, wherein said groove portions are substantially triangular in cross section.
4. A spread illuminating apparatus according to claim 1 or 2, wherein the interval between said groove portions is decreased as the distance from said bar-like light source increases.
5. A spread illuminating apparatus according to claim 1 or 2, wherein the depth of said groove portions is increased as the distance from said bar-like light source increases.
6. A spread illuminating apparatus according to claim 1 or 2, wherein an angle defined between each of said groove portions and the side of said transparent substrate opposing said bar-like light source is in the range of 10 to 45 degrees.
7. A spread illuminating apparatus according to claim 1 or 2, wherein said bar-like light source comprises a bar-like fluorescent tube.
8. A spread illuminating apparatus according to claim 1 or 2, wherein said bar-like light source includes a bar-like transparent light conductive member and a light emitting diode which is provided at the end portion of said bar-like transparent light conductive member.

Abstract of the disclosure

The present invention provides a spread illuminating apparatus in which a transparent substrate is illuminated thereby illuminating a liquid crystal panel provided close to the transparent substrate in order to enhance the illumination luminance and also suppress the interference fringes. In a spread illuminating apparatus in which a square transparent substrate is provided close to the surface of a liquid crystal panel, and a fluorescent tube as a bar-like light source is arranged on the side surface of the transparent substrate, a plurality of straight groove portions are formed on the surface of the transparent substrate intersecting one another obliquely with respect to the four sides of the transparent substrate. While the convergence of the rays of light is carried out only for the component thereof vertical to the groove portions, in the present invention, since the groove portions are formed in such a manner as to intersect one another, the rays of light which are emitted in different directions are all converged, whereby the luminance is remarkably enhanced. In addition, the groove portions intersecting one another suppress the interference fringes of the rays of light.

Fig. 1

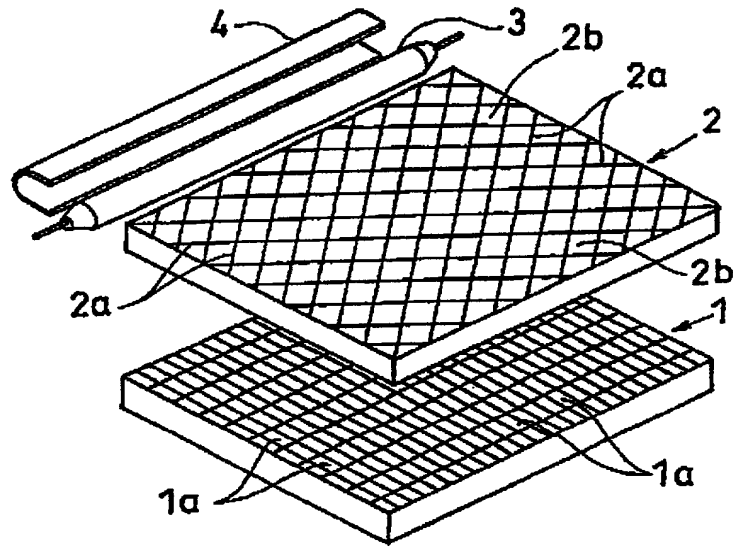


Fig. 2

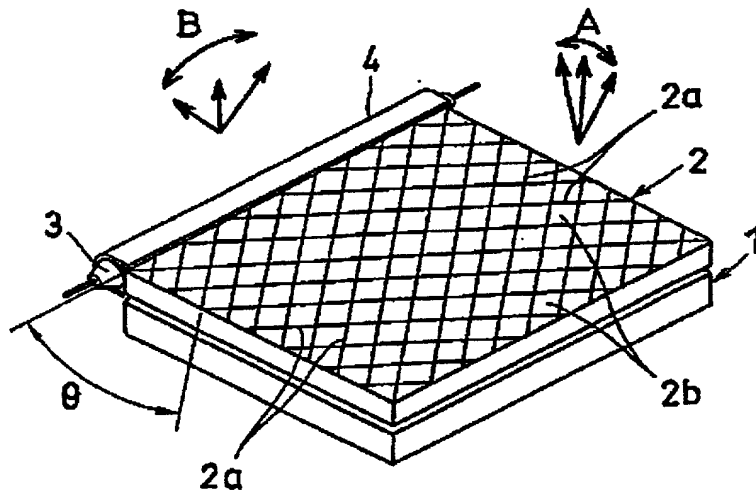


Fig. 3

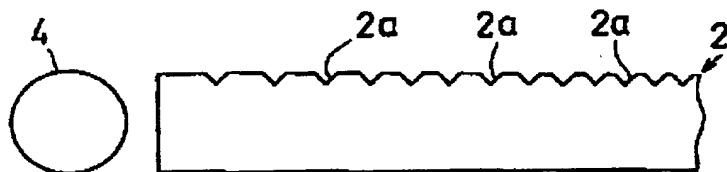


Fig. 4

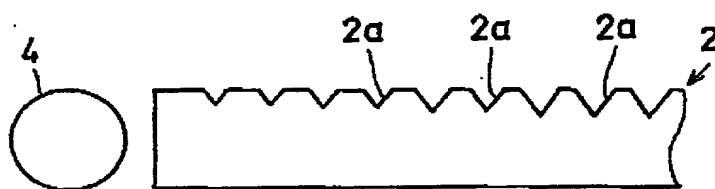


Fig. 5

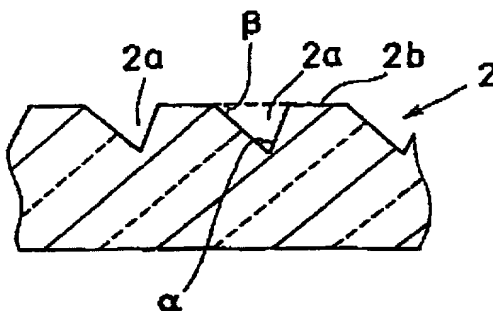


Fig. 6

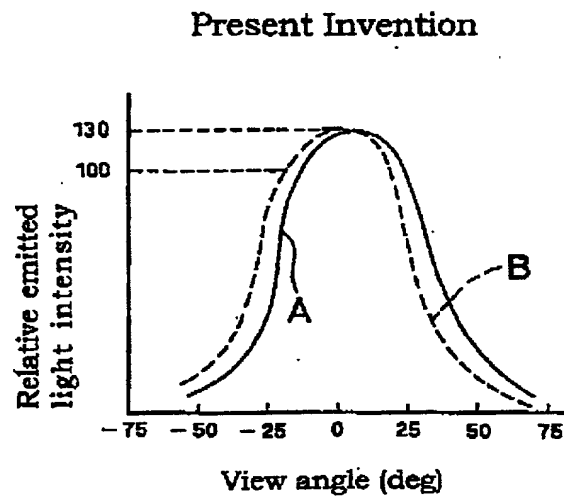
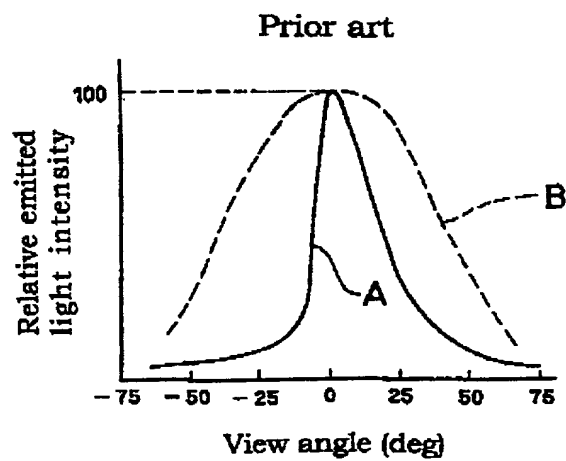


Fig. 7 (Prior art)



APPLICATION FOR UNITED STATES PATENT DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name; that

I verily believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural inventors are named below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

SPREAD ILLUMINATING APPARATUS WITH TRANSPARENT SUBSTRATE HAVING
GROOVE PORTIONS OBLIQUELY ARRANGED AND INTERSECTING ONE ANOTHER

described and claimed in the specification:

Check one

*a. ☒ attached hereto.

b. ☐ filed on _____ as Application No. _____ and amended on _____
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, §1.56. Under Title 35, U.S. Code §119, the priority benefits of the following foreign application(s) and/or United States provisional application(s) filed within one year prior to this application are hereby claimed:

Japanese Patent Application No. Hei 11-235496 filed on August 23, 1999

The following application(s) for patent or inventor's certificate on this invention were filed in countries foreign to the United States of America either (a) more than one year prior to this application, or (b) before the filing date of the above-named foreign priority application(s) and/or United States provisional application(s):

I hereby appoint the following as my attorneys of record with full power of substitution and revocation to prosecute this application and to transact all business in the Patent Office:

James A. Oliff, Reg.No.27,075; William P. Bertridge, Reg.No.30,024; Kirk M. Hudson, Reg.No.27,562;

Thomas J. Pardini, Reg.No.30,411; and Edward P. Walker, Reg.No.31,450.

ALL CORRESPONDENCE IN CONNECTION WITH THIS APPLICATION SHOULD BE SENT TO OLIFF & BERTRIDGE, P.O. BOX 19928, ALEXANDRIA, VIRGINIA, 22320, TELEPHONE (703) 836-6400.

I hereby declare that I have reviewed and understand the contents of this Declaration, and that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Typewritten Full Name of Sole or First Inventor	<u>Shingo</u>	<u>SUZUKI</u>
Given Name	<u>Shingo Suzuki</u>	Family Name
**Inventor's Signature		
** Date of Signature	<u>August</u>	<u>22</u>
	Month	Day
Residence	<u>Iwata-gun</u>	<u>Shizuoka-ken</u>
City		State of Province
Citizenship	<u>Japanese</u>	<u>Japan</u>
		Country
Post Office Address	<u>c/o Minebea Co., Ltd. Hamamatsu Manufacturing Unit, 1743-1 Asana, Asaba-cho,</u>	
(Insert complete mailing address, including country)	<u>Iwata-gun, Shizuoka-ken, Japan</u>	

*This form may be executed only when attached to the specification (including claims) at the end thereof if Box a. is checked.

**Note to Inventor: Please sign name exactly as it appears above and insert actual date of signing.

IF THERE IS MORE THAN ONE INVENTOR USE PAGE 2 AND PLACE AN "X" HERE ☐